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Science and Technology for Tomorrow's Air and Space Force

SUCCESS STORY

Air Force SBIR/STTR

AFRL SPONSORED RESEARCH IN AMORPHOUS SILICON THIN-FILM SOLAR CELLS WILL ENABLE HIGH-POWER, HIGH-RADIATION SPACE APPLICATIONS

AFRL, through a contract with United Solar Ovonic Corporation (USOC), of Auburn Hills, Michigan, has demonstrated high-efficiency, lightweight amorphous silicon (a-Si) solar cells. These thin-film solar cells are deposited on a polymer substrate for production in a roll-to-roll, high-volume manufacturing process. The effort achieved beginning-of-life efficiencies of 9.44 %, which translates into a cell-level specific power of >1000 W/kg.

Air Force Research Laboratory
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Accomplishment

AFRL established a program with industry partner USOC to build on technology developed under a previous AFRL Small Business Innovation Research (SBIR) project. Under the earlier effort, AFRL leveraged USOC's existing terrestrial solar cell product (a solar cell optimized for use on earth and deposited on a heavy 5-mil stainless steel substrate) to develop a product applicable for space use.

USOC modified its existing deposition process to optimize the solar cell for the solar spectrum outside the earth's atmosphere. The company also developed a process for thinning the stainless steel substrate, thus significantly reducing mass. In parallel, USOC accomplished research and development (R&D)-level work to demonstrate the feasibility of producing high-efficiency a-Si solar cells on a polymer substrate in a high-volume manufacturing process. USOC technicians deposited the a-Si layers on the polymer/stainless steel cladding to create the solar cell; they subsequently etched off the stainless steel, leaving the polymer as a substrate.

The resulting solar cell has a specific power >1000 W/kg. The original USOC terrestrial product exhibited a specific power approximating 115 W/kg, whereas the specific power of the a-Si on a thinned stainless steel substrate was ~500 W/kg. These figures translate into an array-level specific power as high as 250 W/kg, in contrast to a crystalline multijunction array with specific power typically around 50-70 W/kg.

Background

While crystalline multijunction solar cells remain the preferred technology for the majority of satellite builders, the associated power levels achievable in space are limited to ~30 kW due the rigid nature of these arrays and the volume constraint within a typical launch fairing. The efficiencies of thin-film solar cells are significantly lower than state-of-the-art multijunction solar cells (~10% versus 30%), but because they can be deposited on thin, flexible, lightweight substrates, they enable fabrication of solar arrays having a much higher stowed-power density than that of crystalline multijunction solar arrays (~10 kW/m3 versus 80 kW/m3).

For this reason, thin-film solar cells show promise in enabling high-power platforms for space use. In addition, these solar cells are inherently radiation hardened. In high-radiation environments, crystalline multijunction cells would require a cover glass so thick as to make their use impractical.

The inherent radiation hardness of thin-film solar cells should enable missions in extremely high-radiation orbits, where crystalline multijunction cells degrade too quickly. Lastly, because manufacturers use large-area deposition techniques for thin-film solar cells, they project thin-film solar cells to be three to five times less costly than crystalline multijunction solar cells and possibly more suitable for large power requirements.

Space Vehicles
Emerging Technologies
(Sustainment)

Additional Information

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